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XI.—*On the* Ventriculidæ *of the Chalk; including the description of peculiar Characters of Structure observed in their Tissues.* By J. Toulmin Smith, Esq.

[With two Plates.]

Almost one hundred years have now elapsed since Guettard drew attention to "some fossil bodies little known," the elucidation of which he attempted in an elaborate paper*. Of the two classes of bodies described by him it is clear that the *Choanites* are one. The figures and descriptions appear conclusive on this point, and the true affinities are very shrewdly pointed out by the writer, while the prevailing notion of the bodies described being petrified figs and other fruits is completely disposed of. It may not perhaps be quite so clear that the other class of fossil bodies described by Guettard comprises some of the forms of the Ventriculidæ. The true characters of the Ventriculidæ will be presently seen to be in almost all cases so obscured from the general observer, and even, without careful attention to the mode of observation, from the experienced palæontologist, that we cannot expect to find in either the figures or description of a century ago positive evidence of identity. Still I think those of Guettard warrant the conclusion that objects of this class were before him.

It was not till Dr. Mantell in 1814 figured and described in the 'Linnæan Transactions,' vol. xi. p. 401, "a fossil Alcyonium from near Lewes," that any particular attention appears to have been given in this country, or, since the time of Guettard, in any other, to these bodies. That paper was but one among the many

* Mém. de l'Acad. Royale de Sciences for 1751. The paper is erroneously cited by Parkinson under the year 1757. I have found no other direct notice of it. Michelin, in his 'Iconographie Zoophytologique,' p. 121, cites M. Guettard's 'Mémoires Académiques.' I have been unable to obtain that work, but conceive it to be merely a reprint of M. Guettard's various scientific papers, including the one above named.

results of the indefatigable labours of its author in a field then little trodden and by few feet. The views expressed in it seem to have undergone little modification since; for though, apparently rather in deference to the opinions of others than from any conviction of his own, changes of opinion on some points have been expressed by Dr. Mantell in later works, they are expressed without any grounds being stated whereon they were adopted*. It can be no reflection on the Discoverer of the Wealden and First Investigator of the Chalk to show that, amid the multitude of objects which engaged his attention, one was not followed out exhaustively. It is sufficient at present to say that, whatever Dr. Mantell may have left undone in reference to the Ventriculidæ, has been hitherto filled up by no other hand.

The different members of the large family of Zoophytes have done so much towards the actual formation of the solid crust of the earth, that anything which relates to any branch of it must be interesting and important; and it is certainly remarkable that, amid the great attention given within recent years by so many eminent observers to this family, no one has entered on an investigation of the Ventriculidæ. And yet the wide development of these forms and their great elegance and variety cannot but have attracted the attention of all who have ever glanced at the contents of any good and extensive series of chalk fossils;—an elegance and variety which the most untutored eye cannot fail to notice and admire.

I doubt not that the difficulty of the investigation affords the real explanation of the neglect to which these bodies have been subject. To investigate the living structure and affinities of an entirely soft-bodied animal whose only remains have come down to us encased either in intractable flint or in friable chalk will be at once felt to be a task of no ordinary difficulty. Such a task is very different from the examination of any living forms, to whatever class they may belong, or even from that of any of the more solid fossil forms, which latter themselves however call into activity the greatest patience and skill of the ablest observers.

Space will not permit me to examine in detail all the notices which have incidentally been taken of different forms of the Ventriculidæ. I must confine myself to a brief glance at the different works in which any direct allusion to these bodies may be found, leaving it to the full details hereafter to be given of

* I allude particularly to the separation of "*Ocellaria*" in the 'Medals of Creation,' p. 279; to the stating Ventriculites to be a composite instead of single animal in note to p. 272 of the same work; and to the still more remarkable entire separation of "*V. quadrangularis*" (p. 283 *ib.*) and placing it among *Flustræ*.

the results of my own investigations to show wherein the figures and descriptions in which such allusions consist have erred or fallen short.

To the paper of Guettard I have already alluded. It is sufficient further to say, that he was not content with that mere superficial glance which most later observers have given. He expressly says* that, though at first he regarded these bodies as related to the sponges, he was obliged to abandon that idea when he had given a more careful attention to the examination of them; and he concluded that their nearest affinity was to the Madrepores.

In 'Edvardi Luidii Ichnographia' (1760), tab. 2. fig. 176, is figured a Ventriculite, which he describes (p. 10) as "Astroitæ congener Radularia cretacea."

Parkinson, in his 'Organic Remains of a former World' (1807), alludes to the paper of Guettard, and gives descriptions and figures of several fossils which he considers as allied to *Alcyonia*, but whose differences from which he yet felt to be marked. Plate 9. (of vol. ii.) figs. 2, 6, 9 and 10; pl. 10. figs. 12, 14, 15 and 16; and pl. 12. fig. 9 I consider to be certainly forms of Ventriculidæ; and I think it probable that pl. 11. figs. 1 and 6, and pl. 12. fig. 8, are so also†.

In Mr. Parkinson's later 'Outlines' (8vo, 1822) he makes some sound observations on the necessity for separating from the *Alcyonia* the various bodies figured and described in his former work, but he gives no additional details of importance.

On p. 54 of the 'Outlines,' Mr. Parkinson, alluding to what are undoubtedly true Ventriculidæ, describes them by characters which are purely external, and treats as generic characters those which are merely accidental and non-essential.

The 'Organic Remains' of Parkinson did not in the least degree forestall the labours of Dr. Mantell, whose figures and descriptions (1814) convey far more information on the subject than all else that has even yet been published. It is but justice therefore to extract at some length the description given by him of these bodies.

The generic characters assigned by Dr. Mantell, as corrected in his very valuable work on 'The Fossils of the South Downs' (1822), p.168, are :—"Body inversely conical, concave, (1) *capable of contraction and expansion*: original substance spongeous? or gela-

* Mém. p. 259.

† The frontispiece to the second volume, which is mentioned by Mr. Rose (citation below, p. 339) as "so beautifully delineating" the structure of the Ventriculite, is no Ventriculite at all, but an exceedingly different fossil in all respects, viz. a Wiltshire sponge.

tinous ?*: (2) *external surface reticulated* †: (2) *internal surface covered with openings or perforated papillæ*: base imperforate, (1) *prolonged into a stirps, and* (1) *attached to other bodies.*"

Of the characters thus described as generic I shall hereafter show that all those which I have put in italics are erroneous; those marked (1) being altogether in opposition to the fact; those marked (2) being characters which are merely accidental and non-essential.

In describing these bodies in the above-cited paper Dr. Mantell says:—"The specimens which occur at Lewes, though generally considered as *Alcyonia,* do not entirely conform to the characters of that genus as given by modern writers; yet they are evidently very nearly allied to it. It is certain that the recent animal possessed great powers of contraction and expansion which enabled it to assume various dissimilar forms. In a quiescent state it was more or less funnel-like; when partly expanded cyathiform; and when completely dilated it presented the figure of a broad circular disc. To this versatility of shape is to be attributed the great diversity of appearance observable in its reliquiæ, whose forms must have been derived from the contracted or expanded state of the original at the period of its introduction into the mineral kingdom. That the animal enjoyed the power of contraction and expansion above ascribed to it, will appear evident from an investigation of its structure. The epidermis or external coat is composed of *fasciculi of muscular fibres, which, arising from the pedicle, proceed in a radiated manner toward the circumference, and, by frequently anastomosing, constitute a retiform plexus* capable of dilating, lengthening and contracting, according to the impressions it received ‡. The fasciculi are further connected by lateral processes §, which increase the firmness and coherence of the external integument. From the inner surface

* This language and query show that the author had found no specimen which enabled him to ascertain the actual internal structure.

† The "reticulation" here meant was merely that of the "*anastomosing tubuli*" named by Parkinson (8vo, p. 54), and has no reference whatever to the beautiful reticulated fibrous structure hereafter to be described, and which appears never to have come under Dr. Mantell's notice. If proof of this remark were wanted, it is found as well in the extract which follows from the paper in the 'Linnæan Transactions' as in the *specific* description given by him in the same page (South Downs, p. 168), where he speaks of the "external integument composed of *cylindrical, anastomosing fibres, radiating from the centre to the circumference.*"

‡ Mr. Parkinson had already expressed a similar opinion as to some of the fossils above named as figured by him. See 'Organic Remains,' vol. ii. p. 145.

§ These lateral processes are in reality the fibres going off to the polyp-skin hereafter described.

of the muscular envelopment arise innumerable tubuli, which pass direct to the ventricular cavity, and terminate in openings on its surface. In *some specimens* a substance of a sponge-like appearance fills up the interstices between the tubuli, and probably is the remains of a membrane which served in the recent animal to connect the tubes and assist in strengthening and uniting the whole mass. The sides of the ventricular cavity are generally about one-third of an inch in thickness. From the bases or pedicle proceed fibres by which the animal was attached to its appropriate habitation."

The portions of the structure here described as internal, and considered by Dr. Mantell to be absorbents, are in the 'Wonders' and 'Medals' of Dr. Mantell considered as polyp cells, and the animal described as a composite and not a single one. I shall show that each appropriation of those so-called tubuli is erroneous.

The paper in the 'Linnæan Transactions' is accompanied, as is the description in the 'South Downs,' by many figures, the truthfulness of which, as conveying the general characters of outward form, has never been even approached by any later writer.

M. Ramond in his 'Voyage au Mont Perdu' (before 1815; but this is the only case in which I have been unable to obtain access to the original work) figured the silicified remains of one species and the cast of the same under the two names of *Ocellaria inclusa* and *Ocellaria nuda,* assigning to them characters which a very little study of the nature of flint and of the process of fossilization would have prevented.

In the first edition of Lamarck's 'Animaux sans Vertèbres,' (1816, vol. ii. p. 187), the bodies thus figured and described by Ramond are included. In the second edition of that work (1836) Milne-Edwards expresses doubts (p. 291) of the correctness of the description which had been given of the *Ocellaria,* but without affording any fresh insight into the real structure of the fossils. In the same edition are included (p. 459) three species of what Goldfuss had previously named *Coscinopora,* and which is a form of the Ventriculidæ.

William Smith, the "Father of Geology," in his 'Strata Identified' (1816), figures two Ventriculidæ in flint (tab. 3. figs. 1 and 2), of which the first is a very characteristic figure. He calls them *Alcyonia.*

In the 'Icones Fossilium Sectiles' of König (1820), Ramond's figures are copied (pl. 8. figs. 98 and 99), but without any description.

In the 'Exposition Méthodique des Genres de l'ordre des Polypiers' of Lamouroux (1821) the so-called *Ocellariæ* are also figured and described, p. 45. pl. 72. figs. 1, 2, 3, 4, 5, but with no fresh information.

The Ventriculidæ were justly considered by Conybeare and Phillips so interesting and remarkable that a larger proportionate space is devoted to their description in the well-known 'Outlines of Geology' (1822) than to any other fossil, and they are the only fossils figured throughout their volume (p. 76). They only however abridge the description given in Dr. Mantell's paper, suggesting, however, that they were composite instead of single animals as described by the latter.

In Goldfuss's 'Petrefacta' (1826) there are given, under still new names, figures which appear to represent some of the Ventriculidæ. I think it quite clear however that the two forms which alone are referred to in Mr. Morris's 'Catalogue' as figured by Goldfuss (*quadratus* and *radiatus*, pl. 33. fig. 1, and 65. fig. 7) are not figures of any of the family of Ventriculidæ. Goldfuss himself (p. 243) refers the genus *Ventriculites* to his genus *Scyphia*, though it is clear one of his *Coscinoporæ* is a Ventriculite also.

It appears to me that the following figures in Goldfuss represent forms of Ventriculidæ; but there is nothing in the descriptions which enables us to identify them: tab. 2. figs. 8, 9, 10, 11, 12, and perhaps 15 and 16; tab. 3. figs. 1 and 5; tab. 30. fig. 10; and perhaps tab. 32. figs. 3 and 8. It is to be observed however with respect to all these figures, that they are too imperfect to enable me to speak with absolute confidence of any one. It is certain that he has no figure of any one of the most characteristic forms of Ventriculidæ. And this is not the less the case though he professes to give magnified views of some of the structure; those magnified views themselves exhibiting, without exception, want of accurate observation, and so being calculated to mislead rather than aid the inquirer.

Mr. Rose published in vol. ii. of the 'Mag. of Nat. Hist.' (1829) a paper "On the Anatomy of the Ventriculites of Mantell," in which he professes to detail the intimate anatomical structure of those fossils, and accompanies his descriptions with figures. The figures however, which are in wood, are not such as to convey any correct or clear idea of the originals, while the whole paper certainly does not elucidate the structure further than had been done by Dr. Mantell*. The writer considers them single animals like the *Actinia*.

* I had proposed briefly pointing out the cause of the essential errors into which Mr. Rose has fallen, but my limits prevent (see note *ante*, p. 75). The course which I subsequently show to be absolutely necessary to the investigation of these bodies is the best explanation of the imperfect and erroneous notions hitherto prevailing in regard to them.

In Miss Bennett's 'Catalogue of Wiltshire Organic Remains' (1831) are given, but again without any description, the best figures yet published of one form of the Ventriculidæ, which is there called *Choanites subrotundus* (tab. 16. figs. 1 and 2: figs. 3, 4 and 5 are bad).

In Woodward's 'Geology of Norfolk' (1833) two figures are given (tab. 4. figs. 20, 21) of what the author calls *Ventriculites infundibuliformis*, but unaccompanied by any description, and the figures are too indefinite to afford any information: the author includes *V. radiatus* in his list (p. 46).

Blainville, in his 'Manuel d'Actinologie' (1834), figures on pl. 76. figs. 4 and 4 *a* the *Ocellariæ* of Ramond, and on pl. 60. fig. 5 the *Coscinopora* of Goldfuss; but in his description of each, pp. 386, 430, he intimates doubts as to their real nature. He describes each, however, as having a stony polypidom!

Phillips, in his 'Illustrations of the Geology of Yorkshire' (1835), vol. i. p. 118, gives several figures, unaccompanied however by any description, and which figures are so very imperfect that it is impossible to make out from them any character at all. It would indeed be impossible to know that any of them represented Ventriculidæ, did not the heading of the list of figures state such an intention. This imperfection of these plates is the more to be regretted, and the absence of all description the more surprising, inasmuch as the able author himself remarks (p. 121), that "the remains of the [so-called] *Spongiæ** are nowhere so well-developed as in England, and perhaps nowhere in England so well as in Yorkshire. On the shore near Bridlington they lie exposed in the cliffs and scars, and, being seldom inclosed in flint, allow their organization to be studied with the greatest advantage."

Bronn, in his 'Lethæa Geognostica,' (1835–7) allows a place to two of the Ventriculidæ under that name, and figures another under Goldfuss's name of *Coscinopora* (tab. 29. fig. 1). He figures Goldfuss's *Scyphia Oeynhausii* as *V. radiatus* (tab. 27. fig. 18), in which he is clearly mistaken. Neither the figure of natural size nor magnified has any resemblance to any of the Ventriculidæ.

In 'Die Versteinerungen des Norddeutschen Kreidegebirges' of Roemer (1840) are figured, with very meagre descriptions, some forms which seem intended to represent some of the Ventriculidæ. They are however too indefinite to enable me to fix

* Though thus called "*Spongiæ*" by this author, and though some other writers have so called them also, it is really needless to expend one line in showing the total absence in them of all resemblance to sponges. No two classes of objects in natural history can be more different, and the affixing of such a name can only arise from an entire want of opportunity for the examination of specimens.

with confidence on particular figures. All are described under the name of *Scyphia*. The nearest forms are perhaps tab. 3. figs. 2, 9, 11, and tab. 4. fig. 1, but others are probably intended for these objects.

In Portlock's 'Report on the Geology of Londonderry' (1843) are contained descriptions, but no figures, of *Ventriculites radiatus* of Mantell, and *Scyphia alternans* of Roemer (tab. 3. fig. 9), and also of the one figured by Goldfuss (pl. 30. fig. 10) as *Coscinopora infundibuliformis*; but this writer does no more in effect than repeat the descriptions given by former authors.

Michelin, in his 'Iconographie Zoophytologique' (1843–7), has figured (pl. 30.) and described (p. 121) under the name of *Guettardia*, a variety of the Ventriculite already figured by Dr. Mantell (South Downs, tab. 15. fig. 6) under the far more characteristic name of *V. quadrangularis*.

On pl. 38. fig. 3 of the same work is a very imperfect figure* of *Ventriculites Bennettiæ*. On pl. 41. fig. 3 is a far better figure than had before been given of the so-called "*Ocellaria nuda*;" while on pl. 40. figs. 3 *a* and 3 *b* are figures of what he calls *Ocellaria grandipora*, being really a very different species of Ventriculite from the other so-called *Ocellariæ*. These figures admirably represent the original as it appears when first broken out of the flint. The description (p. 145) contains however, in this as in other cases, nothing new. On pl. 40. fig. 4 *a*, 4 *b*, is also represented, under the name of *Retepora crassa*, another form of Ventriculite.

In 'Die Versteinerungen der Böhmischen Kreideformation' of Reuss (1846) no new details are given, while the figures (tab. 17. fig. 14, and tab. 18. fig. 11) are remarkable, in a work marked by the general beauty and correctness of its figures, for the want of any character or truthfulness whatever.

Such are the notices of this very interesting class of bodies which I have met with. Doubtless others may exist in works which have not fallen into my hands. The above will satisfy every reader that all that has been done by recent palæontologists has been to copy from one another. It is important to observe that in none of the figures or descriptions which I have cited does there exist the slightest indication of what I shall show to be the actual structure of these remarkable bodies, and without an insight into which all attempts at classifying them and determining their affinities must necessarily be uncertain and unsatisfactory and a true knowledge of their natural history impossible. Dr. Mantell is, indeed, the only author who has presented

* Probably a mere copy,—for Michelin's plates are usually very good and characteristic.

us with an extensive series of figures and descriptions. And although, as he himself properly remarks*, "some respectable writers have amused themselves with either giving them new names or arranging them as *Spongiæ, Alcyonia,*" &c., those writers have assuredly done nothing more; and thereby, instead of advancing the knowledge of these fossils, they have introduced all the confusion and uncertainty which it has been possible to do as to even their identity.

Dr. Johnston, in his 'British Zoophytes' (2nd ed. 1847, p. 180), merely takes a passing notice of the Ventriculidæ; but his work does not profess to include fossil species.

Finally, Mr. Morris, whose wand has in many instances restored order where numberless writers had "amused themselves with giving new names," while he properly readmits the Ventriculidæ to their position as a separate genus, has placed them among the *Amorphozoa*. It is needless to dwell on the impropriety of that position, as Mr. Morris is now fully satisfied, from an inspection of my collection, that they deserve a very different place. And if constancy and elegance of form, delicacy of structure, and a high state of organization are to be taken as tests, the Ventriculidæ will assuredly have hereafter to be ranged in a very different group from that of the *Amorphozoa*.

Having thus shown what has been already done in the field upon which I have entered, it is necessary, in order that the reader may have any confidence in the results and observations which will be presented to his notice here, to state the course which I have myself pursued in these investigations.

The first specimen of the Ventriculidæ which came under my notice strongly attracted my attention from its great elegance of form and the peculiarities I observed in it. I was disappointed in finding any satisfactory information on its nature, and soon perceived that every one of the characters described in the books had reference to some superficial characters only, and not to the intimate structure of the animal. Being fully satisfied that "it is only by a strict investigation of the *intimate structure* of the various forms of these animals," as an accurate observer has well remarked†, "that any permanent arrangement that shall indicate their true and natural affinities may be hoped for," I set about that task myself: this has now engaged my attention for upwards of two years; and in now publishing the results of my careful observations, I feel that I may add with even more truth than could be done by that writer, that the task I have undertaken "is a task of no little difficulty in the accomplishment,

* Geology S.-E. England, p. 97.

† Farre on the *Ciliobrachiata*, Phil. Trans. 1837, p. 387.

and one that may fairly entitle him who enters upon it to expect to meet with indulgence,"—an indulgence, however, which those best qualified to judge of the value of such observations will, happily, be also most able and willing to yield*.

My first step was to obtain as large and varied a series as possible. I have in truth examined and compared with laborious care several thousand specimens, of which certainly upwards of one thousand are at this time in my own collection. These specimens are in all conditions and from various localities.

But I soon felt a new difficulty. These bodies exist both in the chalk and in the flint, substances about as different as well may be. I saw that much error and inconsistency had arisen from not comparing and regarding the differing conditions in which these fossils exist in such different substances. Hence a preliminary step seemed to be, an examination of the nature and mode of formation of the flints themselves. The conclusions resulting from that examination have, to a great extent, been communicated in two papers in the 'Ann. and Mag. of Nat. Hist.' for January and May of the present year.

The exposition given by Dr. Turner† of the *origin* of the siliceous fluid,—in the solution of silex consequent on the disintegration of the felspar of igneous rocks, at which moment of disintegration the silex is liable to free solution in water,—was consistent and satisfactory. But no consistent or satisfactory view could be discovered explanatory of the modes and forms in which the *flint* is actually found. I endeavoured in the above-cited papers to show that those modes and forms are owing to the very rapid solidification of the siliceous fluid—induced by special circumstances—combined with the activity of molecular attraction: that those special circumstances were generally the presence of an organic body which acted as a nucleus,—the softer bodies being more operative in this respect than the harder: that some-

* One of the most pleasing duties of the student of natural history is to acknowledge and reciprocate the assistance received from, and always so ready to be rendered by, other naturalists. I take this opportunity of acknowledging my obligations to Professor Owen for, among other things, affording me the opportunity of fully examining several recent specimens of the highest interest, some of which I shall have occasion particularly to mention hereafter; to Mr. Morris, the well-known author of the 'Catalogue of British Fossils,' for assistance rendered in more ways than it would be easy for me to enumerate; to Mr. Tennant of the Strand, and Mr. Harris of Charing in Kent, who have each placed at my disposal several valuable specimens with the liberal permission to make any sections I desired; and to Miss Emma Naylor of Wakefield for the donation of many fine specimens of recent British Polypifers collected by herself. To many others my acknowledgements are also due, for the loan of specimens, both fossil and recent, for examination and comparison.

† Lond. and Ed. Phil. Mag. vol. iii. p. 25.

times mere mechanical action was sufficient to induce solidification. I further showed* that from these facts certain very remarkable and hitherto unnoticed results had followed; namely, that when a mass of the siliceous fluid had solidified thus suddenly round a soft body, a Ventriculite for example, in which the soft parts were existing at the time of its envelopment, it necessarily formed a solid mould round the nucleus: that when the soft body decayed, its gases and softer components having escaped through or been absorbed by the surrounding and hardening chalk, a more or less complete hollow was necessarily left in the solid flint in the place formerly filled by the animal body: that the firmer fibre of such bodies remaining after the softer parts had thus passed away would afford and did afford centres of crystallization for any silex slowly permeating the stratum in a liquid or gaseous form after that stratum had acquired consistency: that according to the greater or less quantity of such permeating silex would be the result in either wholly or only partially filling up the hollows whose origin I thus explained. I showed the accordance of these views with the known laws of the development of crystals†.

The most important results follow from these observations; and I immediately saw that that which had been generally described as the remains of the body itself was in truth the incrustation of a crystallized foreign substance round such remains. It will be obvious how erroneous must be all descriptions founded upon the former notion.

It remained to adopt a mode of examination of the Ventriculidæ in chalk and in flint which should realize the living animal in the same form from an inspection of its remains in either matrix. To effect this I made many sections of chalk specimens in every direction, for examination both as opake and transparent objects, —an attempt which I believe was novel. Aware that it is by

* Ann. and Mag. Nat. Hist. vol. xix. p. 306.

† The mode of crystallization most commonly exhibited in these cases is the acicular. Silex is known to crystallize in this way from sublimation. In the 2nd vol. of the 'Transactions of the Geol. Soc.' p. 274, is a paper by Dr. MacCulloch on an instance observed by him of the actual formation of such crystals, which he there describes aptly as "filamentous crystals crossing each other in all directions." It seems to me, from careful observation, that it was in cases where an almost or altogether entire hollow was left, all the fibre having decayed as well as the soft parts, that the geometric crystals were more disposed to form within the flints. The centres were fewer, the space larger. A botryoidal form is frequently assumed under such circumstances by the aggregation of acicular crystals; and traces of its former existence are visible in many now solidly filled spaces. The greater or less degree of slowness of the deposit no doubt had an important influence in determining the silex to assume the geometric form of so-called quartz or the botryoidal form of so-called calcedony; the quartz being the result of a still slower deposit than the calcedony.

careful personal manipulation only that results can be obtained which may be relied on, I further procured the necessary machinery and made a large number of sections, in every possible direction, of numerous *entire* flints*. The results have far surpassed my most sanguine expectations. I have not only discovered, beyond possibility of question, the intimate structure of the Ventriculidæ,—and in so doing have discovered an entirely new and most remarkable form of animal tissue,—but I shall be able to show the cause and character of all the modifications of form under which the Ventriculidæ are found; and I further hope to afford indications (I wish to express myself here as cautiously as possible) of the natural affinities and habits of the living bodies to which these very interesting fossils owe their origin.

It should be remarked, that the difficulties in the way of observation of structure in chalk specimens is no less, in reality, than of those in flint. The very friable nature of the chalk, coupled with the almost invariable presence of oxide of iron, would be sufficient to obscure and practically to obliterate a structure far less delicate than that of these bodies. Hence the coarser superficial characters which have been seized upon by all authors as characteristic of genus are all that is usually visible. It was not without much difficulty and care that I succeeded in examining satisfactorily the intimate structure of these bodies as actually preserved in that matrix.

It will clearly be only by thus gaining an insight into the true comparative values, if I may so speak, of the facts exhibited by remains preserved in both chalk and flint, that the inquirer can be in a position usefully to commence his researches with the hope of reaching any definite and satisfactory results.

We find specimens of the Ventriculidæ preserved in flint in one of three ways: the place of the body either wholly solid, the crystallized silex having entirely filled up the original hollow: partially solid, and that is generally towards the central parts of the flint,—the marginal parts, and especially the roots, remaining the last to be solidly silicified: or, lastly, the whole occupied by an open network only. Each case may be examined with great instruction, the key to what it teaches having first become thoroughly understood upon the principles above indicated, to the deduction of which principles instances like these were steps, and of which they do but afford illustrations.

It follows from those principles that, where the calcedony†, whether solid or open, began by crystallization round some re-

* The sections of flints usually examined by microscopists are of mere chips and fragments. They can be of no value in an investigation of this nature.

† See note Ann. and Mag. for May last, p. 307.

maining fibres of the body as centres, the fibre itself, when by this process hermetically sealed up, would remain there to this day in much the same condition as it then was, usually more or less charged with sulphuret of iron; and that, where not so hermetically sealed, it would, on its subsequent decay, either leave the incrusting calcedony in the condition of a series of hollow tubes, or such hollow tubes would, still subsequently, be again filled up by a continuation of the process of siliceous crystallization. I have many specimens of the Ventriculidæ in each of these conditions. It will further be obvious, that where, as occasionally might happen,—but comparatively rarely, because dead fibre would have less attraction for the siliceous fluid than soft animal matter,—the fibrous skeleton of an animal of which the soft parts had already decayed away was enveloped in the siliceous fluid, no hollow would ever be formed, but that fibrous skeleton would be preserved hermetically sealed. I have instances of this latter mode of preservation also.

The flint specimens are, in the vast majority of cases, found with flint on both sides; a fact resulting, there can be little doubt, from the operation of some cause connected with electricity, which, though there is in no part any communication between the two surfaces, determined an attraction and affinity between equivalent masses of siliceous fluid on the two opposite sides, just as we see the needle follow the magnet though a solid plate intervene. Cases are however not very uncommon in which the flint exists in a mass only on one side, there being on the other merely narrow filamentous threads of flint. When the mass is thus found on one side only, that side is, in almost all cases, the inside. Now the Ventriculites being funnel-shaped, there would necessarily be a much greater attraction for the siliceous fluid on the inner side of the body than on the outer side, in precisely the proportionate difference that there is between a single exposed plane surface and a surface closed in on all sides by opposite surfaces. If a mass of siliceous fluid were not great in a particular spot, the greater part of it would thus be drawn to the inside, the electric attraction before hinted at operating however generally to attract a small portion to the outer corresponding surface, where it would spread in what now appear as filamentous threads between the foldings of the outer surface of the animal, in which spots the greatest attraction on the outside would of course be, in consequence of the opposite surfaces there present*. Occasionally a similar appearance is found both on the external and internal surface; but that is usually towards the margin of a flint which is otherwise encased on both sides, as in the specimen fig. 2 of my paper of January, and betokens an exhaustion

* See and cf. p. 9 and note to p. 301 of the two articles before referred to. The threads of flint are there found though the body was not encased.

of material. It would sometimes happen that a very small mass of the fluid would approach the outside only of a large Ventriculite. In such case none could reach the inside, and we should find, and do, that it is external only.

It may at first sight be thought that there would be hollows in chalk specimens similar to those in flint, and that these would be as subject as the latter to have any inclosed fibre incrusted with calcedony. A little reflection will however satisfy the careful reader that this could not be the case. The mould of the individuals inclosed in flint was perfectly solid. Though sulphuretted hydrogen were evolved, which it necessarily would be, from the decomposing body, the encasement in that solid matrix would generally prevent the so free deposit of sulphuret of iron as would take place in the open chalk. Consequently the remaining fibre would offer more affinity for the gaseous silex than would such fibre remaining in the open chalk and more highly charged with sulphuret of iron. And the fact is, that specimens preserved in the chalk exhibit a much larger proportion of sulphuret of iron than those preserved in flint,—frequently so much that the specimen, after a short exposure to the air, becomes a mere mass of oxide of iron, and all structure is undistinguishable. In other cases it is less so, and I have in fact found, in several chalk specimens in which the presence of iron is the least marked, that the deposit of crystallized calcedony*—pure and without the presence of a particle of flint on either external or internal surface—has taken place to a small extent, but in a most exquisite manner. It is clear however that, in general, when any part of the *soft* substance of a body encased in chalk decomposed, its place was soon filled up with particles of chalk, which in its then scarcely hardened state were readily carried in. The firmer fibre would, thus inclosed, endure for a much longer period, probably indeed until the chalk had become comparatively dry, on which event its absorption, where little sulphuret of iron was present, would follow and the space be left vacant. The instances of calcedonized fibre in chalk specimens are then quite as frequent, and to just such an amount in individual cases, as might be anticipated, while the frequent excellent preservation of the forms of the Ventriculidæ in the chalk is also explained.

A piece of dead fibrous skeleton in the chalk would evolve but little sulphuretted hydrogen, consequently would induce the deposit of little sulphuret of iron. It follows that, when buried in the chalk mud, it would be at once closely encased. The hardened chalk would, on the absorption of all the components of the fibre, also leave the places of those fibres vacant. On cutting open these, as well as on cutting open specimens encased with their soft parts and whose phænomena it is above attempted to ex-

* *Not flint*:—it is important to remember this.

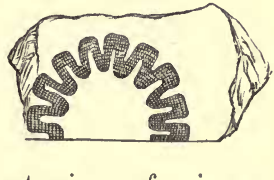
plain, we should find the places of the fibres indicated by hollow tubes disposed through the mass. Of course the presence of great pressure, or the percolation of water or other causes, will have frequently destroyed every trace of the animal, or partially destroyed it, leaving perhaps a mere iron-mould to mark its place; if the fibre were dead, not even that. I am fortunate in having some very beautiful specimens of the dead fibre tubes in my possession,—specimens which naturally escape ordinary attention, there being no colour to attract the eye, and the aid of the microscope being necessary to detect the facts.

In my notes I find several other points examined, but the space to which I am necessarily restricted prevents my entering into further detail here, and I think that I may rely on the candour of every competent observer, that, having thus far touched on material points, others which may occur to him have not escaped my attention. Proceed we now to the *results* of these observations.

I propose to point out, first, some of the general and most important characters connected with the external form of the *body* of the living animal; second, the same of the roots; third, to show what is the intimate structure of both; and lastly, to endeavour to indicate the natural affinities of the whole group. And though it is impossible for me to do otherwise than painfully feel that the attempt is vain to convey, by a few words and figures, that certainty of conclusion which I have derived from such very extended observation, I will hope to impart some consciousness of a reality.

Every reader familiar with the human brain is aware that it consists of a very extensive surface folded up in numerous convolutions in order to pack it in the small compass of the skull, just as for convenience the pocket-handkerchief is doubled up to put it in the pocket. The remarkable resemblance between the annexed section of a Ventriculite (in flint) in my possession, and any cross section of the cerebellum cannot fail to strike every reader,—a resemblance arising from the simple circumstance that both are examples of a similar mode adopted by nature for packing an extensive surface in a small space*. But no one will pretend to assert that those ridges, of which the outline is seen in the section of the cerebellum, are "cylindrical fibres;" nor will any one infer a power of expansion

Fig.
C



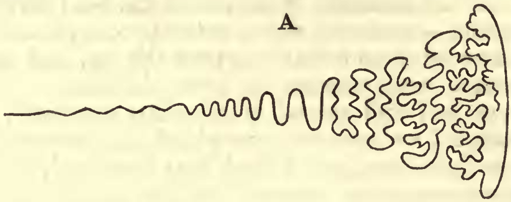
* Plates 63 B, 64, 64 A, and 64 B of Prof. Owen's 'Odontography' afford striking illustrations of the application of the same contrivance to the hardest, as in the brain it is applied to one of the softest, of organic tissues.

and contraction to reside in these bundles, as Parkinson* and Dr. Mantell have done, from a similar appearance, in respect to the Ventriculidæ.

A glance at the following figure will satisfy any one that a simple and plain membrane may be folded up in the most intri-

Fig.

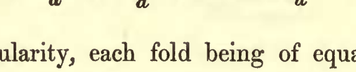
A



cate way without in fact destroying its simplicity, and having the only effect of packing a larger surface into a smaller compass. The mode of folding may be either longitudinal, in which case we shall have the "cylindrical fibres radiating from the basis to the circumference" of Dr. Mantell; or it may be transverse; or it may be more or less intermediate between the two, thus causing those longitudinal ridges to appear to anastomose; or it may be so regularly intermediate as to give to the surface a mammillated appearance. The appearance of the body may even differ on the external and internal surfaces, inasmuch as the folds may assume a different direction as they reach the respective surfaces, as we see familiarly in a rhubarb leaf just burst from its sheath. But none of this can alter the nature of the membrane itself, or serve to establish a generic character. It is further evident that if the folding assume the mammillated character,—that is, if a membrane of some thickness be folded in and out in regular figures,—a section across any part will, according as its direction shall be, represent a series of apparent tubules or of reticulations regularly disposed, as seen in Pl. VII. figs. 1 to 4; and again, that if any foreign substance fill up any of the superficial depressions on this mammillated surface, that surface will appear to be regularly perforated by tubules. Hence the figures of Goldfuss and Roemer, which profess to give magnified views of the exteriors of Ventriculidæ. The following figure will illustrate this: *a, a,* is the membrane, which is folded in and out with

Fig.

B



the exactest regularity, each fold being of equal breadth and

* Organic Remains, ii. p. 145.

length, thus making each depression and elevation regularly round. It is evident that a section made in any part from *b* to *b*, in the plane of the surface, would be more or less of the character of Pl. VII. fig. 3, while a section made in any part perpendicular to that plane would resemble the upper part of fig. 4, or fig. C (p. 87).

A very careful examination and comparison of innumerable entire specimens and sections, both in chalk and flint, of every form and variety of Ventriculidæ, early satisfied me that, though contrary to every figure and description that has been published, the above was the true explanation of their forms. Every subsequent observation has confirmed this conclusion. Let the reader examine Pl. VII. figs. 1 and 2, and fig. C (p. 87), and he will see three out of many of the modes in which transverse sections of Ventriculidæ in my possession show that the membrane is folded. Let him, again, examine Pl. VII. figs. 1 and 2, and he will see in fig. 1 a surface perfectly plain and smooth, except so far as the fibrous structure marks it; while in figure 2 he will see the lower part of the surface smooth like fig. 1, but the upper part gradually passing into the mammillated character. These varieties (never before figured) are both in my possession, and I have every shade and variety from the perfectly plain to the most convoluted form of fig. A above. It will easily be conceived what a variety of markings in the chalk and flint,—at first sight wholly inexplicable and unconnected,—will be presented on longitudinal and transverse sections of such complicated convolutions.

Nor does such variation in external form indicate in the least degree a habit or power of contractility. I have shown, by analogy, that it does not necessarily do so. I will show by actual facts that the Ventriculidæ were not contractile. Not only is it an important fact that we find deeply convoluted specimens as wide-open-spreading as any, while we find specimens of the perfectly plain varieties as narrowly funnel-shaped as any, but we find, fixed on the surfaces of specimens of every variety, Ostreæ, Dianchoræ and other shells which are in the habit of attaching themselves by peculiar processes to other bodies. In every such case the shape of the attached shell *departs from its ordinary form*, and is precisely adapted to, *moulded on,* that of the Ventriculite—proving that it *grew thereon,* and thus testifying at once to the firmness of the texture of the body and to its noncontractility, as well as to its durability. Further, we sometimes find delicate Flustræ spread over parts of Ventriculites—always, as before, without trace of distortion or disturbance. But there is, if possible, yet stronger evidence in the fact that an entire and very large group of the Ventriculidæ, and those, too, the very ones which are pointed out as exhibiting the most "contracted state," have distinct heads—which heads are perfectly smooth and regular in general form, and with no deep anfractuosities, instead of being, as the contractile theory requires, most of all convoluted. Finally, I shall presently show that there was a special and most beautiful provision in the intimate structure of these animals against contractility either voluntary or by ordinary accident.

Nor is there any want of examples of the presence of similar convolutions without contractility in what I hope to show to be kindred zoophytes of the present day. The *Eschara foliacea* is familiar to every one. But I am indebted to the kindness of Professor Owen for a still more striking illustration of this arrangement in a recent zoophyte. That gentleman a short time ago placed in my hands, with the liberal permission to examine it in any mode I chose, a specimen of *Meandrina* recently brought from the Indian Ocean, and which had been treated with muriatic acid. All the calcareous parts being thus dissolved, there remained only the soft animal parts. I observed with much gratification that these consisted, in fact, of a single membrane folded up almost exactly after the manner of some of the more irregular of the Ventriculites—very much indeed like the *Ventriculites radiatus* described by Mantell and others as having an "integument formed of cylindrical fibres anastomosing," &c.

However much differing in the complexity and mode of the convolution of its membrane, the body of every member of the family of Ventriculidæ appears to have had an opening at its upper part, and that body approached more or less to the form of an inverted cone. They usually grew single. In one or two species they are grouped, and there are occasional instances, but very rare, of double specimens of those whose usual habit is single —just as we occasionally find a double *Actinia*.

Having thus shown the general character and habit of the body of these animals, I next proceed to show the nature of the root.

The attention of Ellis was particularly attracted, in describing his Corallines, to one variety, the *Corallina astaci corniculorum æmula* as he calls it, or Lobster's Horn coralline, as having roots very different from those of ordinary corallines, "which rise up from an irregular mass matted together to form the stem*." The roots of this zoophyte, on the contrary, "regularly enter in in whirls round the joints;" the body of the animal, according to his figure, tapering off to a point in the midst of these root fibres†.

Something after such a type was the habit of the roots of the Ventriculidæ. They were *not*, as described by Dr. Mantell, de-

* Ellis's Corallines, p. 16 and pl. 9. B.

† This peculiarity is not marked either in the description (p. 86, 2nd ed.) or figure (pl. 19) of Dr. Johnston; but the figures and descriptions of Ellis are seldom unworthy of dependence.

rived from the base of the body "prolonged into a stirps and attached to other bodies." The body of the Ventriculite tapers off regularly to a point at the bottom. At about an inch from its base,—the distance varies according to size,—fibres of a very different aspect from those composing the membrane of the body begin to be attached to the external part of that body. They do not begin all round at exactly the same distance from the base, nor, as they increase in mass, is that mass of the same thickness on all sides. They are at first very few and thinly disposed. As the base narrows they increase rapidly in number and mass, till, immediately below the base, they form a bundle of considerable size, which is continued, thus united, for some distance, from one to three inches according to circumstances, when it divides into several radicles, sometimes more, sometimes less: I have counted as many as forty in one specimen. These sometimes extend very far and always terminate in very delicate extremities.

The root-mass is never itself convoluted like the body, even in its upper parts, and where it forms a thin membrane only. It necessarily follows the form of any convolution, usually slight, which exists at the lower part of the body. The mass of the root is not regularly cylindrical, but irregular on the different sides (see Pl. VII. fig. 6). Occasionally it assumes a tubular aspect in places, but this is quite accidental and in nowise characteristic of genus or species.

Pl. VII. fig. 5 gives a longitudinal section in which the difference between the body and root is very clearly seen: fig. 6 is a transverse section of the same specimen. These two will realize to the observer how admirably the body was lodged in this root-case as in a sheath or socket. They remind one of a balloon to which the car is attached by a network of rope gathered in on all sides round the narrow base. Pl. VII. fig. 7 is the external appearance of another specimen, showing the root-fibres commencing round the body and spreading at the root.

The substance of the root was different, as the fibres were differently arranged from those of the body. This is proved by the fact that the root exists generally in a very different condition, both in chalk and flint, to that in which the body is found in the same specimen. In flint its place is much less often solidly filled with calcedony than is that of the body. In the chalk it is the rare exception to find the substance of the root in sound condition. It generally falls away to dust the moment the specimen is opened, while the body of the Ventriculite remains entire and perfect down to its very point, having all around it a hollow space where the root was.

The Ventriculites were never "affixed to other bodies." It is possible that the animal was locomotive like the *Actinia*, and that, like the *Pennatulidæ,* it fixed itself during pleasure in the soft mud. Among all the thousands of specimens which I have examined, I have never seen one attached to a shell or to any other solid body. Shells are indeed sometimes found *growing onto* the *upper part* of the root, where it was of course immoveable, as they do on the body. The most delicate terminations of the roots may be always traced by their impression in the chalk. If the animals were locomotive, it was by aid of the lower radicles that they progressed.

Occasionally, but it is the rare exception, a small bundle of root fibres is given off from the side of the animal. This is similar in character to the true root, but slighter, and it is merely affixed by apposition of its thick extremity, without any of the encasement. Such instances appear as if some circumstance rendered an additional support necessary in the particular instance. There are instances among our native zoophytes of upright habit, in which a similar circumstance is not uncommon —much more common than among the Ventriculidæ.

I have one example in which there is no encasing root-sheath. And in that specimen, as if to make up for want of it, the rootlets begin to arise about an inch from the base, being already of considerable strength: they spread out immediately on each side, and so support the body just as a tent is supported by the staying ropes on all sides. I have another example having two complete roots, and of course a divided base to the body. Each root is however smaller than usual. These examples only show that the world was under the same laws in the days of the chalk formation as it now is: that then, as now, monstrosities would sometimes appear, which, however, only themselves serve to show the permanence of Law and Unity, inasmuch as in these very monstrosities there is always present some compensating phænomenon which it is interesting and instructive to observe.

I have already stated that my investigations into the *intimate structure* of the Ventriculidæ have rewarded me by the discovery of an entirely new kind of animal structure.

In 1841 Professor Owen read before the Zoological Society a paper* on a remarkable production from the Philippine Islands, of which he says, "in the exquisite beauty and regularity of the texture of the walls of the Cone, the species surpasses any of the allied productions that I have, as yet, seen or found described," and he gives to it the very appropriate name of *Euplectella.* While the *Euplectella* is the only object which approaches the Ventriculidæ in the beauty and regularity of its texture, the latter far surpass it not only in possessing a much higher degree

* Zoological Transactions, vol. iii. p. 203; and Ann. and Mag. Nat. Hist. vol. viii. p. 222.

of that very beauty and regularity, but in the exquisite delicacy of a further texture, of which the *Euplectella* does not possess a trace, and which, so far as I can learn from the best authorities, has never been hitherto observed in any object, animal or vegetable, recent or fossil.

Through the kindness of Professor Owen and the liberality of the proprietor of the specimen, Mr. Broderip, I have had an opportunity of carefully examining the *Euplectella*. While I am thus enabled to speak to the fidelity of Prof. Owen's description, I can also speak with more assured certainty as to points to which, having the structure of the Ventriculidæ before my eye, my attention was more particularly directed.

The *Euplectella* is composed of an arrangement of fasciculi of fibres, *one course over the other*, not anastomosing together: its principal substance consists of two layers, a longitudinal and a transverse one, of which the former is external to the latter. These, thus crossing at regular intervals, form the regular texture which excites Prof. Owen's just admiration,—an arrangement in which they are held by the interlacement of other and more delicate fibres tied by the same fairy fingers which Dr. Johnston describes as knitting the plexus of one of his delicate zoophytes. The squares thus formed are about the eighth of an inch in size,—gigantic in comparison with the squares filling the membrane of the Ventriculidæ.

The membrane of the Ventriculidæ is composed of very delicate fibres arranged in squares, of which the larger ones measure, on an average, considerably less than the 100th of an inch on each of their sides*. The fibres of the Ventriculidæ are not arranged in fasciculi, nor in layers the one overlying the other concentrically or otherwise. Neither are they at their points of crossing wrapped together by other interlacing fibres. The substance of the *Ventriculites simplex* (see Pl. VIII. fig. 1), which is the true type of the whole family, is not quite one line in thickness (about the sixteenth of an inch). It consists of five thicknesses of the squares I have mentioned. Consequently the substance of the body of the animal consists of a membrane composed of an exceedingly delicate fibre anastomosing in every direction, so as to form both in the plane of its surface and of its thickness regular squares (see Plate VII. fig. 8). As the body increases in size from the base to the upper margin the fibres increase in number, and this takes place, not, as in the *Euplectella*, by the "convergence and interblending of contiguous fibres," but by the addition of a fresh fibre, generally at the middle of the outward boundary fibre of a

* The sizes are pretty constant in different species. There is some variation however. Those described are the largest. The *relative* dimensions appear constant.

square,—thus causing less disturbance to the regularity of the squares than happens in the *Euplectella* (see fig. 14). But this is not all the beauty and delicacy of the intimate structure of the Ventriculidæ. A structure remains to be described, to which the expressions of Prof. Owen in describing the *Euplectella* may well justify me in saying that no language can do justice, and which no one can contemplate without delight, wonder, and exquisite admiration.

If the reader's attention has ever been attracted by the roofs of the large railway stations, he will have perceived that they are held together by the mutually counteracting and balancing effects of thin rods obliquely placed—any one of which would singly be very inefficient for any substantial purpose. To give a barred gate strength, or to keep a loose door or window-frame to its true square, we see the carpenter fix a bar obliquely subtending the right angle, which will hold the more securely the nearer it is fixed to each side at equal distances from the angle. The principle of the bracket which supports a shelf or bust is but the same.

But there is nothing new under the sun. Ages before railways or carpenters existed, nature had adopted this very plan, to give strength and stability to the deep ocean forms of the whole family of Ventriculidæ; only, as she ever does, adopting a method far more delicate, complete and beautiful than it were possible for the hand of man to execute.

I have said that the fibre is arranged in a tissue of regular squares, which are formed by the anastomosing, at each angle, of that fibre. But, besides these fibres, of which there necessarily occur at each angle three entire ones crossing each other, or six looking at them as radiating from the angle as a centre, these crossing and anastomosing fibres are strengthened and secured by twelve still finer oblique fibres, each about one-fourth of the length of any one square itself. Each of these fibres subtends one of the angles formed by two of the primary crossing fibres, and of which angles there are of course at each crossing twelve. Each of them anastomoses with one pair of the primary fibres in each position in which they meet to form a right angle. This anastomosis takes place at an equal distance on each primary fibre from the angle itself, namely, at a distance of about one-fifth of the length of one side of the square. Thus it will be seen that at each place of crossing there are twelve subtending fibres and six primary fibres, in all eighteen fibres. Now, taking a Ventriculite of very moderate size, say three inches in height and plain, we shall have a membrane containing at least 750,000 squares, and at least nine million of these delicate subtending fibres, each faultless. What a marvellous piece of workmanship is this!

It will be perceived that by this most admirable contrivance a regular octahedron is formed round about the point of union of every four squares throughout the whole body of the Ventriculite, thus forming, of course, as many octahedrons as there are squares. See Plate VII. fig. 8, and more clearly fig. 10, as seen in flint, and fig. 9 as seen in chalk*.

It is needless to point out the strength given to the whole membrane by this arrangement, and the obvious design of it to prevent any injury of the animals to which it belonged arising from any yielding or distortion to which it might otherwise be liable from the operation of ordinary causes present in the ocean where they dwelt. They generally suffered fracture rather than yield to such impulse.

As the texture reaches the surface, both external and internal, it assumes a different appearance in order to attach to it the more securely what I shall crave permission to call, for the present, the *polyp-skin*. The regular squares and their octahedral junctions are still present, but under a different aspect; their size being contracted to about the 300th of an inch. This appears to be effected by the *addition* of finer fibres crossing each other within each square, so as to make at least four squares equivalent to each of the larger ones. This membrane presents a solid series of these squares; that is, they extend, in a single layer, as well in the plane of its thickness as of its superficies. The membrane spreads over every convolution and descends every anfractuosity of the body. Plate VII. fig. 11 shows this membrane in calcedony, where several of the actual fibres are preserved and the crystallization round them is very visible.

External to the whole, the polyp-skin itself,—spread over both external and internal surface and depressed also into each of the anfractuosities,—stretches over the delicate membrane last described, with which it is closely united (see Plate VII. figs. 12 and 13, and Pl. VIII. fig. 6). In specimens both in flint and chalk, prepared with care and in a high state of preservation, an equidistant row of apparent denticles seems to extend from the inner substance to the external encasing wall. This is caused by the transverse fibres (in the flint, incrusted with calcedony; in the

* It is obviously impossible to find individual specimens which shall fully show those states of fact which have been only ascertained by careful examination of many hundred specimens. Again, the least obliquity in any section will cause an *apparent* elongation of some and a cutting off of parts of other squares; while the slightest variation in focus will cause fibres in different planes to appear on the same plane. Hence, oftentimes, an *apparent* irregularity which does not really exist, but which may easily deceive an unpractised eye either in the object itself or in the engraving. Figs. 8, 11, 13 and 14 illustrate this. It should be added, that the octahedral structure could not be given with any clearness in figs. 8, 9 and 14, without somewhat exaggerating its relative size. No engraving can do justice to the exquisite delicacy of the original.

chalk, the place of the fibre left hollow and the intervals filled with chalk) of the delicate membrane which underlies the polyp-skin.

The polyp-skin itself is of extreme tenuity, and differs altogether in structure from the internal parts. It is not fibrous, but of a uniformly close texture which yields to the highest powers of the microscope no other than a minutely granular appearance.

It is only in very rare cases that the polyp-skin is found in any degree of perfection. Careful observation and comparison of an immense number of specimens, *with their casts,* led me to infer the existence of this polyp-skin, as matter of unevadable conclusion, long before I was fortunate enough to find, as I have since done, specimens in which it was so preserved as to be found on the body of the fossil itself. In such cases as the latter, the internal structure is always clearly seen where any parts of the polyp-skin are ruptured. See Pl. VII. fig. 12.

I shall presently enter on the consideration of the polyps themselves and the accompanying phænomena.

It will of course be understood that the membranes I have described must, during the life of the animal, have been filled with soft parts, which, with whatever minutely ramifying vessels they contained, rapidly decomposed, and of which therefore I have as yet discovered no trace.

There existed no spiculæ, siliceous or calcareous, in any of the Ventriculidæ; some spiculæ in the adjoining chalk or flint may sometimes deceive an inexperienced observer.

The structure of the root differs much from that of the body. Annexed to the body by short fibres clearly seen on a good section, it is, like the body, arranged in squares, but those squares have not all that regularity which those of the body have. They are, in general, smaller in their average size than those of the body, and have throughout a tendency to elongation in their longitudinal direction, whence they are often narrowed on one or both of their lateral planes. The fibres of the root are also thicker in their longitudinal direction than in their transverse.

It is particularly important to observe that there is no trace in the roots of the octahedral structure, a fact precisely in accordance with the functions of those roots. The safety of the animal would be more secured by the latter yielding to every impulse, and waving their so delicate load from side to side, than by an unbending stiffness. The octahedral structure had therefore no place in the roots.

The integument of the root was also very different from that of the body. It is impossible for a moment to confound the two. Its longitudinal fibres were much thicker than the transverse ones; and, there being no octahedral structure to secure an unyielding exactness, it appears as if disposed in long, narrow, and not very regular meshes. When encrusted with calcedony it appears not unlike some vegetable tissues (see fig. 7. Pl. VIII.). The deceptiveness of appearances thus caused has been already fully pointed out. This integument was very possibly muscular.

The fibres of the roots, like those of the body, all anastomose together. They do not overlie nor entwine.

When it is remembered that sulphuret of iron is deposited more or less on every fibre that has been actually preserved, it will be obvious that it is impossible to ascertain the exact size of the recent fibre. I have however frequently observed the better-preserved fibre to be less than the 4000th of an inch in diameter in its present condition; much appears about the 2000th of an inch; and the coarser and less perfectly preserved rarely exceeds the thousandth of an inch in its present condition. The fibre is single and solid (never fistular). It is generally found both in flint and chalk reduced, more or less, to its ultimate granular texture, in which case it resembles the granular texture of other animal fibre. This granular texture is finer, even in its present condition, than that of the recent *Actinia*.

The description of another most interesting point which I have discovered in connexion with these animals—the ovarian cells—will more properly come under the next division of the subject, when the natural affinities of the animal are considered. I content myself for the present with stating the fact of the discovery and clear establishment of these ovarian cells, a fact which cannot but be felt by every naturalist to be of the very highest importance, both in relation to the individual beings themselves and as an aid in determining their natural affinities (see Pl. VIII. fig. 3).

And now, having thus too imperfectly described the intimate structure of these animals, so elegant and graceful even in their external forms, I hope that I shall be felt not to have expressed a too strong sense of the exquisite beauty of that structure. I have searched in vain amid zoophytic forms for any structure that may compare with that of the Ventriculidæ in delicacy, beauty, and obvious adaptation. The pride of man may call all those beings who differ most from him in structure the "lower animals;" but I would ask, Where can be found an organization more complex or more exquisitely delicate, or where adaptation more perfect, than is displayed in the structure of the Ventriculidæ? Where can we find a structure affording more conclusive evidence of the all-prevalence of those laws of Unity and Design which it is the grateful task of the naturalist to develope, and of which his inquiries, the further they extend, do but unfold a wider field of illustrations for man to study and admire?

[To be continued.]